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Microwave Assisted Technique for Synthesizing ZnCdO Nanopowder Humidity Sensor

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ABSTRACT

Now a days nano sensors place a vital role in sensing of smell less toxic gases which are polluting the environment. Its active role paved a path in protection of environments from the hazards. An attempt is made by using ZnCdO nanopowder humidity sensor. ZnCdO nanoparticles have been prepared by using a simple household microwave irradiation with an operating frequency of 2.45 GHZ. This technique permits us to produce gram quantity of inhomogenous nanoparticle in just 10min. The variation of conductivity in ZnCdO nanopowder ensures to analyze the sensor behavior easily and humidity controlled electronic devices. The samples were further subjected to photoluminescence (PL), Scanning electron microscope (SEM) studies. The humidity variations are observed inside the solar still along with the water temperature and air temperature. The performance efficiency of the sensor is studied and reported.

Keywords: Nano powder, Temperature, Resistance, Humidity, Efficiency.

INTRODUCTION

The peculiar properties of the nanomaterials such as their electrical, optical and sensing property gives much importance in the recent years for the raise of nanotechnology field in the commercial and industrial nature. To enhance its nature, it’s been a great challenge for the researchers to pay attention in controlling the particle size

and morphology in structure yet the methods recently adopted in preparing the nanomaterials require much time and the instruments of the cost. A novel method for the consistent of such preparation should be considered[1].

Humidity sensors based on semiconducting Oxides have certain advantages. When compared to other types of humidity sensors such as low cost, simple construction, small size and ease of placing the sensor in the operating environment. In metal oxide semiconductors (such as SnO_2, ZnO, WO_3, TiO_2) electrical conductivity changes depend upon the composition of the gas surrounding them. Therefore they are the popular and useful sensing materials for making inexpensive gas sensing device[2].

Till now the methods involved in preparing nanomaterials are microwaving heating, non-aqueous approaches, chemical-precipitation, sol-gel process, gas condensation, hydrothermal process, and aerosol spray process. The ZnCdO semiconducting nanomaterials have a wide band gap with which it can be implied in sensor applications UV photodiodes, piezoelectric devices, acoustic wave devices, transparent electrodes, facial powders[3-8].

Sensors prepared many aspects of modern living, many application demand miniaturization to reduce power consumption for integration into portable device[18]. So for numerous kinds of materials have been utilized for humidity sensing[19] of them metal oxides which are stable physically and chemically, have been widely investigated for humidity detection at both elevated and room temperature[20-21]. The humidity sensors are mostly operated at room temperature on ionic conductivity.

In the present work, we report the bulk synthesis of ZnCdO nanoparticles by microwave irradiation method. This technology is less time consuming (about 10 min) compared to the other techniques which requires 12-24h. To the best of our knowledge this is the first preliminary report about humidity sensing properties of ZnCdO nanoparticles prepared by simple and less time consuming microwave irradiation method.

2. EXPERIMENTAL PROCEDURE

2.1. Material preparations

An appropriate mole of 20%zinc chloride and 80%cadmium chloride solution were prepared separately and mixed together with constant stirring for 15 min. Then ammonia was added drop wise under strong stirring until the pH of the solution reaches 8. When the reaction is complete, an azury precipitate was obtained. This precipitate was washed with water more than ten times until no chlorine ions are detected in the silver nitrate test. The precipitate was further washed with ethanol to remove NH^{4+} ions. The resulting precipitate was kept in household microwave oven for 10min.The radiation frequency was 2.45 GHz and its power was 900w. The dried powders were sintered at higher temperature in the order of 400°C to ZnCdO phase.

3. SYSTEM DESCRIPTION

3.1. Single Slope Solar System

The water storage basin of the still is designed of area 0.50 m x 0.50 m. Bottom

and sides of the still are coated with black paint for good absorption of solar radiation. An inlet pipe of ½ inch is used for pouring water into the still. The outer box for the still is made up of wood of thickness 4mm with the length of 0.70 m and breadth of 0.70 m respectively. The bottom of outer box is filled with the sawdust insulation up to the height of the 0.11 m. The side wall is insulated with glass wool. This insulation reduces the conduction heat loss through the base and sides of the solar still. Bushes are placed at the base of the still for uniform landing in the surface. The top cover of the still is made by the glass of thickness 4 mm. The top cover is placed over the grooves which are provided at all sides for uniform resting. A 15º slope is maintained for top glass cover. Water Collection segment is placed at the desired position for collecting the evaporated water and it is of dimension 0.66 m x 0.038 m x 0.015 m. The outlet pipe of ¼ inch is provided to collect the distilled water from the water collection segment at the height of 0.15 m. A schematic view of single slope solar still shown in Fig. 1.

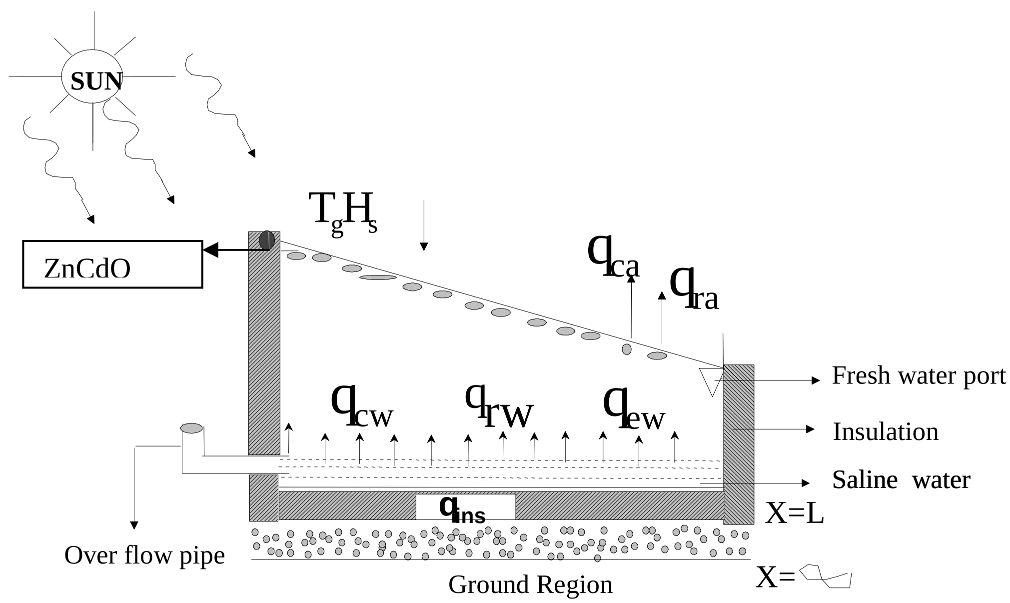

Fig.1. A schematic view of single slope solar still

3.2 Experimental

The experimental work was carried out during the summer of the year 2011 at the solar energy laboratory on the campus of Sri Ramakrishna Mission Vidyalaya College of Arts and Science, at Coimbatore (11°.00 N, 77°.00 E). The data were collected continually after half hour intervals for testing. The measured parameters of the

above experiments were: solar radiation, ambient air temperature, water temperature, inner and outer glass temperatures, distillate collected from the still. Thermocouples were connected to digital temperature indicators. A precession pyrometer is used to record solar radiation. The collected condensate was continuously drained through a flexible hose and stored in a measuring jar. After each scheduled time interval, the water distilled by the still was replaced by raw water so that the mass of the salivated water in the basin was always constant A.

3.3 Humidity Measurement

The experimental work is carried out in Sri Ramakrishna Mission Vidyalaya College of Arts and Science. The solar still of area $0.25m^2$ is fabricated. The saline water in poured inside the still through the separate port. The solar radiation passes through the single slope solar still, and solar energy is observed by the blackened absorber plate. The energy absorbed by the absorber basin is mostly transferred to the water. As a result, water gets heated. The evaporated water is condensed on the inner surface of the top cover by releasing its latent heat. The condensed water, under gravity, trickles down the top cover and is finally collected through a drainage provided at the lower end.

3.4 ZnCdO Humidity Sensor

The successfully prepared ZnCdO nanopowder pellet kept over the water surface. The other end of the device is connected with the LCR meter. Two K type thermocouples were used to measure the water and air temperature inside the still. The entire system is closed without any air leakage with the surrounding. When the water reaches the optimum evaporation temperature, it gets escape from the water surface due to latent heat release. At the same time, some amounts of moisture contents are absorbed by the ZnCdO sensor. The water molecules donate the electron to the semiconducting oxides[9-12]. The electron injection was observed due to adsorption of water on hydroxilated surface of the sensor. The injection of electron was not only from the water molecules and also from the absorbed oxygen ions. Further the adsorption of electron from donor molecules (water) results in a conductivity change. Fig.2 shows the photographic view of sensor device setup.

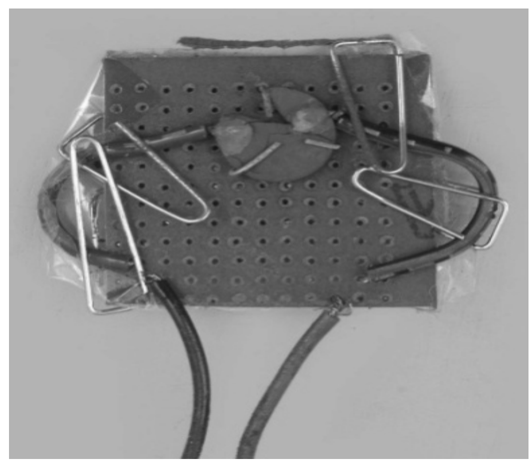

Fig. 2 Photographic view of ZnCdO nanopowder sensor device

RESULT AND DISCUSSION

The XRD patterns of 20%ZnO and 80% CdO are depicted in the Fig.1. The ZnO and CdO peaks are respected by circles and rectangles respectively. The characteristic

peaks corresponding to CdO having cubic phase and orientation along (111) (200) (220) (311) peaks with lattice constant a=5.1906A° and to peaks corresponding to ZnO having pure hexagonal phase with orientation along (100) (101) (200) (201) planes with lattice constants a=4.6813A° are obtained. The data obtained for ZnO and CdO from the expt are very well agree with the JCPDS file no. 05-0640[18] and JCPDS file no.36-1451[19] for CdO and ZnO respectively. The results obtained from the XRD data reveal that the mixture of ZnO (low concentration) and CdO (High concentration) as prepared samples are in oxidation state, owing to the presence of Cd and Zn metal peaks. The XRD patterns are very well match with the patterns obtained from the preparation of 20%Zn 80%CdO by microwave irradiation technique.

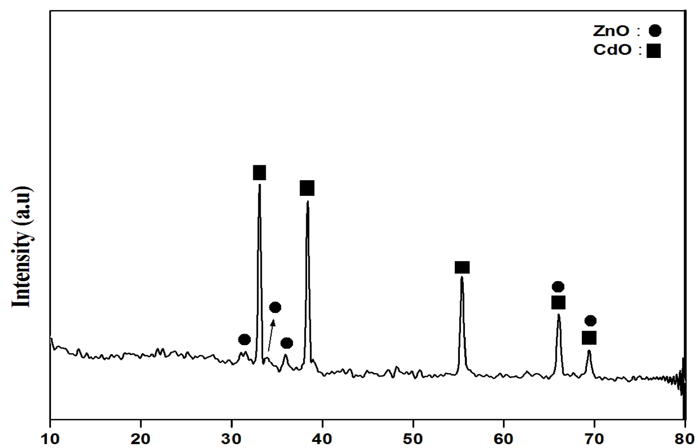

Fig.3. XRD patterns for ZnCdO samples prepared by Microwave irradiation Method

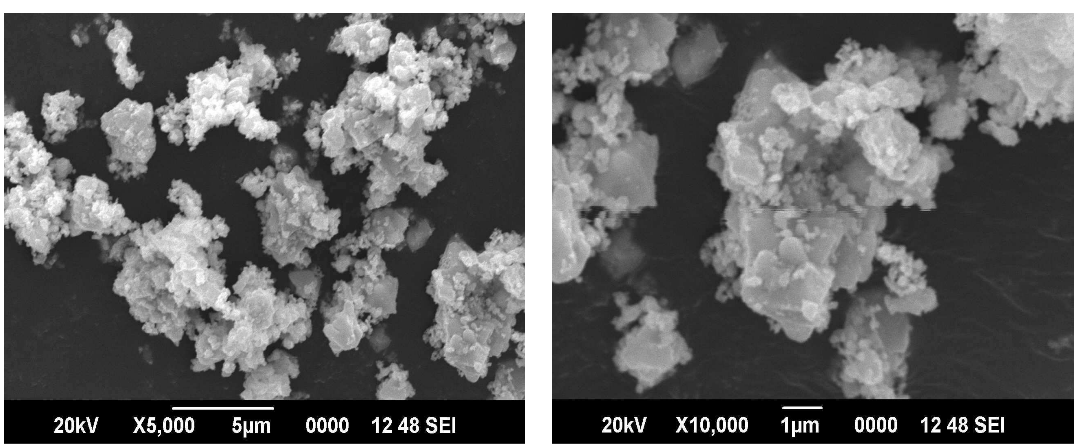

Fig.4. SEM images of ZnCdO samples prepared by Microwave irradiation Method

Fig.2. shows the SEM image of a group of a ZnCdO nanoparticle synthesized in the microwave technique corresponding to the sample in Fig.1. From our previous works[13,14] it was obtained from the cubic shape with agglomeration nanoparticles respectively however the morphology analysis reveals that the as-produced ZnCdO nanopowder in Fig.2 have irregular shapes such as cubic, rectangle, spherical etc.

Fig.5. The intensity of Cd peak is much stronger than that of Zn an oxygen peak, being consistent with the chemical composition mapping in Fig.3 from the results of EDX spectrum the atomic weight percentages of Cd,Zn and oxygen are determined to be about 18.42%, 6.53% and 75.06%.

Fig.6 the optical properties of the sample were investigated by photoluminescence spectroscopy excited with the 324 and 382 nm. Fig.4 shows the PL spectra of the prepared sample. According to the figure a broad ultraviolet emission are observed in PL spectrum of the sample. Annealing at 400°C strongly increases the PL signal, mainly in the visible region, because defects acting as competing nonradioactive channels are reduced. This is broad visible PL band corresponding to remaining defects.

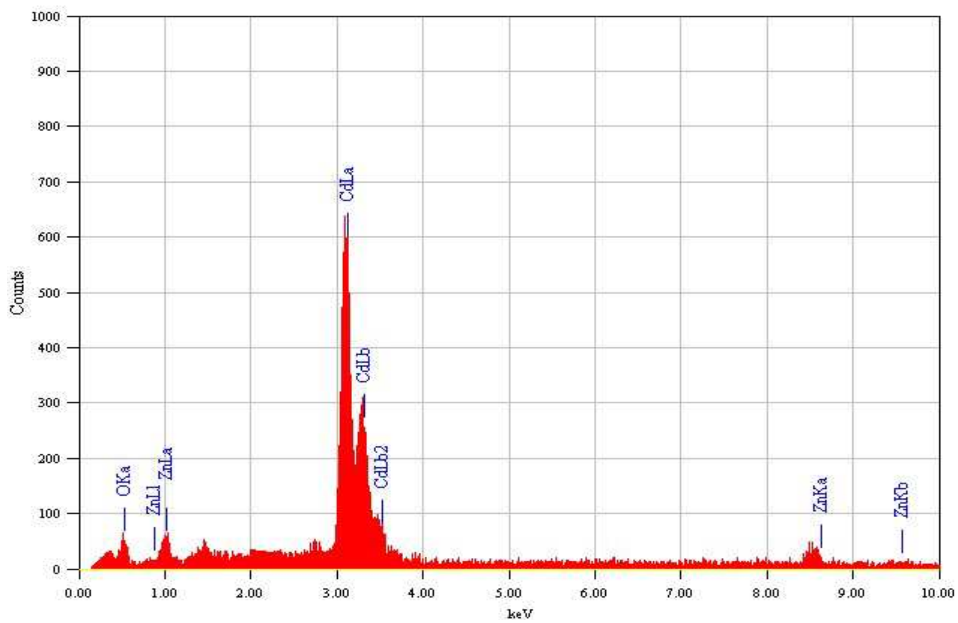

Fig.5. EDX spectra of ZnCdO samples prepared by microwave irradiation method

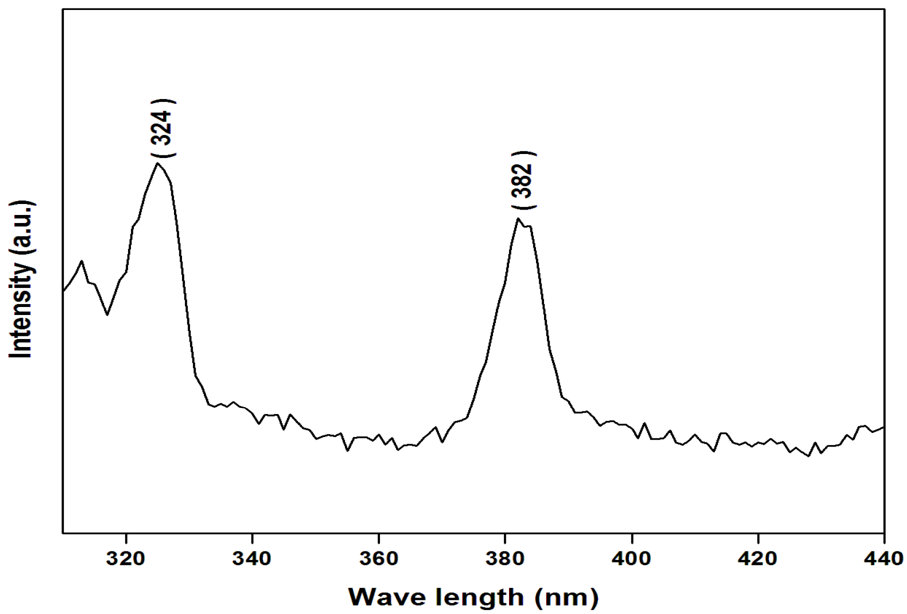

Fig.6. PL spectra of ZnCdO samples prepared by microwave irradiation method

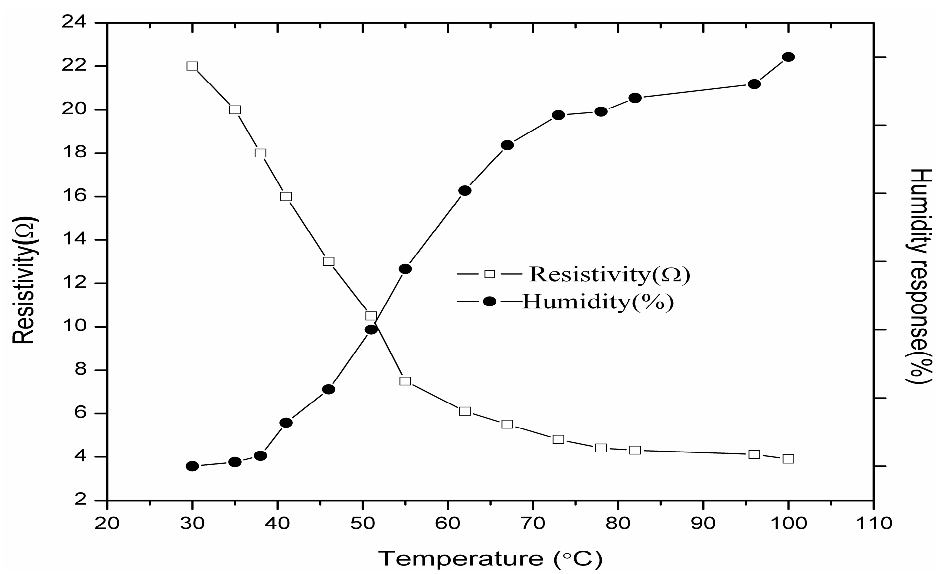

Fig.7. Variation of resistivity and humidity with respect to water temperature

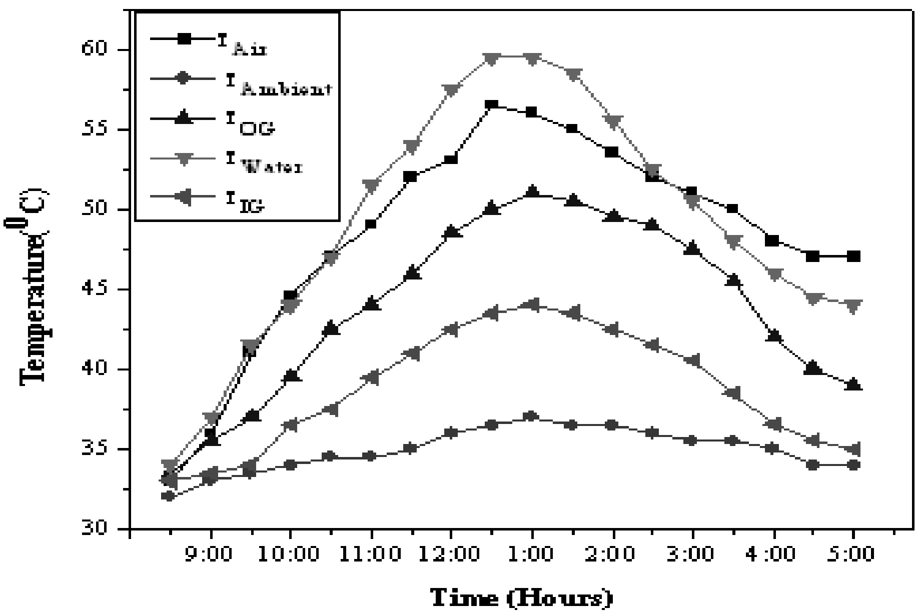

Fig.8. Variation of temperature with respect to time for single slope solar still

Fig.7 shows the variation of water temperature with respect to ZnCdO sensing result and evaporation heat transfer. The evaporate rate is predicted by the sensor which resulted about the maximum value of 22% at higher temperature and decreases to 4% at low temperature. At higher temperature humidity percentage decreases but the distillate yield is change due to higher temperature difference. The increase in water temperature induces evaporation rate inside the still. This brief analysis helps to get the exact humid range for the higher distillate output. Thus ZnCdO nanosensor plays a vital role to predict the humid variation inside the still. If any air leakage and heat losses from the still can also be identified easily by the identification of change in resistance in ZnCdO nanopowder sensor.

Fig.8 shows the variation of temperature for water, air, top cover, ambient, inner cover and outer cover with respect to time. The maximum temperature rise in water is 55 °C. Similarly the maximum air temperature of 58 °C is observed. During this study, the corresponding variation in ambient temperature is in the range of 31 °C to 37 ° similarly the variation of top cover temperature is in the range of 31°C to 39°C.

CONCLUSION

The ZnCdO nanopowder was synthesized by microwave irradiation technique within 10min. The formation of crystalline structure ZnCdO nanoparticles confirmed from SEM and XRD measurements. ZnCdO humidity sensor was

designed and analyzed the sensing property in single slope solar still. These sensors have a very good sensitivity of humidity in the atmosphere. It also helps to maintain the solar still system without any vapor leakage, because this sensor device responses immediately by decreasing resistivity values. This focused as very good humidity sensor.

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